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Project Summary

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Community Health Associated with Arsenic in Drinking Water in Millard County, Utah

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This study evaluates the human health effects of ingesting drinking waters with arsenic at levels about four times the United States Environmental Protection Agency primary drinking water standard. Examinations of 250 cases included dermatological, neurological, and anemia endpoints. Hair and urine were tested for arsenic content. Estimates of water consumption provided the exposure criteria.

One hundred and forty five "exposed" cases drank water with arsenic at 0.18 - 0.21 mg/liter. One hundred and five matched controls were selected from a neighboring community with arsenic at 0.02 mg/liter in their drinking waters. Cases were of either sex, over five years old, and residents of the community for the last five years. Controls were selected by random number selection from within age categories to match age and sex distribution of the exposed population. No exposure of controls to arsenic by use of arsenic-containing chemicals was found.

A clear relationship is shown between amount of arsenic consumed and levels in urine and hair. Dermatological signs associated with arsenic exposure were rare and scattered among exposed and control participants. Anemia, nerve conduction slowing, and signs/symptoms of arsenic intoxication were not found in the study population. Cancer incidence or mortality did not show an excess in the exposed community. No adverse human health effects were discovered among this relatively small population exposed to drinking water with arsenic at four times the primary drinking water standard.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The objective of this study was to determine if a population consuming drinking waters with high arsenic will show more signs and symptoms of arsenic intoxication than a population not so exposed. The toxicity of arsenic compounds is highly variable depending on exposure route, rate and duration of exposure, compound, species of arsenic, and animal species, strain and individual susceptibility. However, the acute toxicity of arsenic is well established and includes gastrointestinal damage and cardiac abnormalities. Chronic exposure produces a variety of signs and symptoms which may include

dermatologic, neuropathy, hematological, cancer, and cardiovascular disease. The ascertainment of signs and symptoms due to chronic exposure is made difficult by their variety, range of disease susceptibility and additional exposure to potential disease causing agents.

Arsenic in drinking waters is limited by a primary drinking water standard from the United States Environmental Protection Agency at 0.05 mg/liter. This maintained the U.S. Public Health Service standard from 1962. Chemical forms of arsenic include trivalent and pentavalent inorganic and organic compounds. It is assumed that the pentavalent inorganic form is the most common in drinking waters. Inorganic arsenic is absorbed readily from the gastro-intestinal tract, lungs and through the skin. Inorganic trivalent forms are slowly oxidized to the pentavalent form. Arsenic is excreted via urine, feces, sweat, and skin. With chronic exposure arsenic accumulates mainly in bone, muscle, skin; with some in liver, and kidneys. Epidemiologic investigations have provided valuable insight into potential human health risks associated with arsenic in drinking waters.

In Taiwan, well water averaged 0.6 mg/liter of arsenic in a community. Predominate signs, symptoms, and illness reported were hyperpigmentation, keratosis, skin cancer, and "blackfoot disease." This study showed the prevalence of skin cancer to increase in direct proportion to the arsenic content of the well water consumed. Water from these wells was used for more than 45 years.

In Antofagasta, Chile mean arsenic levels of 0.8 mg/liter were found. Signs and symptoms predominately of children included weight loss, diarrhea, general debilitation, anorexia, and scaling of the skin. Over 80% of the affected population had abnormal skin pigmentation. Bronchopulmonary and cardiovascular disease was also reported. Other studies have reported neuropathy and anemia. Cancer (not skin) caused by arsenic exposure has not been well established. However, evidence does exist from occupational studies for an increased risk due to arsenic exposure.

Drinking water arsenic levels at 0.1 mg/liter in Lane County, Oregon showed no association to skin cancer, keratosis, or hyperpigmentation. Levels ranging from 0.1 to 1.0 mg/liter in Lassen County, California drinking water were not associated with any specific illness. However, levels above 0.05 mg/liter increased arsenic concentrations in hair. The National Academy of Sciences has suggested that dermatologic manifestations may be a sensitive indicator of exposure to arsenic compounds at levels which could prove harmful.

This study utilized an existing condition of high arsenic levels in drinking waters to study the potential human health effects of this exposure. Exposure was determined by environmental sampling of air and drinking water; estimating individual water consumption through the administration of a questionnaire given to each participant; and measuring levels of arsenic in hair and urine samples. Exposure determination was conducted in both high exposure ($\geq$0.15 mg/liter) and low exposure ($\leq$0.025 mg/liter) communities. Health status was determined by physical examination which included dermatological signs of chronic arsenic poisoning, such as hyperpigmentation, keratosis, vascular changes, and skin cancer; nerve conduction velocities; hematocrits; and a questionnaire relevant to health status. Community death rates and cancer incidence was also determined by record retrieval.

Results and Conclusions

Arsenic exposure estimates considered the air route to be insignificant after monthly sampling for a year. Water consumption patterns showed similarity by community and occupation. Highest consumption of water was by out-of-door summer workers, ranging higher than 8 liters per day. (See Table 1) Estimates of annual arsenic consumed had a range of 12 - 953 mg in the "exposed" and 4 - 135 mg in the "non-exposed" populations. (See Table 2) Arsenic levels in hair and urine were significantly (statistically) associated with exposure to arsenic in drinking waters.

Dermatological manifestations were not evidently associated with arsenic exposure. The mean values for conduction velocity for any given nerve did not vary significantly with respect to age or community. However, a slightly increased proportion of participants with slowing of nerve conduction were among the exposed participants. A trend (not statistically significant) for anemia in exposed communities was also found. Cancer incidence and death rates did not suggest an unreasonable excess of cancer in the exposed population.

The hypothesis that arsenic in drinking waters at these levels would result in ill health was not confirmed by this study. This could be an effect of the form of arsenic in the drinking water. The species of arsenic in the high exposure areas was determined to be 86% As^{+5}. Different forms of arsenic may result in varying degrees of signs and symptoms after exposure.

In this study no adverse health effects were found for exposed people averaging more than 150 mg arsenic from drinking well water per year. This is four times the maximum allowed by the current standard without evidence of adverse health effects.

Table 1. *Daily summer water consumption for residents of three study communities.*

Community	Number of participants	Water Consumption Rate (Liter/day)		
		Mean	Range	Standard Deviation
Delta	105	2.7	0.5 - 12.0	1.9
Hinckley	102	2.9	0.3 - 13.0	2.0
Deseret	43	2.4	0.3 - 8.0	1.4

Table 2. *Annual Arsenic Consumption from Drinking Water for Study Participants from Three Study Communities.*

Community	Number of Participants	Arsenic Consumption (mg)		
		Mean	Range	Median
Delta (Control)	105	24.2	4 - 135	17
"Exposed"	145	152.4	12 - 853	119
Hinckley	102	135.5	12 - 853	115
Deseret	43	192.5	14 - 736	148

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The complete report, entitled "Community Health Associated with Arsenic in Drinking Water in Millard County, Utah," (Order No. PB 82-108 374; Cost: $8.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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